Benefit continued from page 4

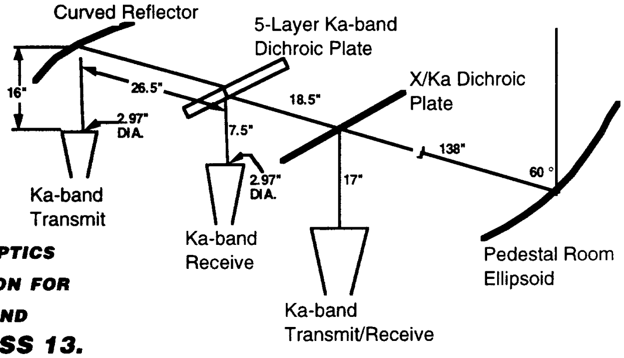

Figure 4. Optics configuration for the X/Ka-band system at DSS 13.

isolation between all transmitter and receiver channels was achieved.

Figure 4 shows the optics configuration and Figure 5 is a picture of the system implemented at DSS 13 as part of this demonstration. Shown are the multiple dichroics and feeds that are used in the beam waveguide configuration that routes the RF signal from(to) the antenna and to(from) the various front-end receiver(transmitter) systems. The line shown in Figure 4 represents the path of the RF signal. The X/Ka-band dichroic plate that separates the two widely separated frequency band signals uses technology developed in 1990 as part of the original support for the Mars Observer Ka-band Link Experiment (KaBLE). The X-band signal is diplexed using a standard waveguide diplexer (not shown in Figure 4), and the Ka-band system is diplexed using the 5-layer plate FSS. A single feed is, therefore, used at X-band, and the transmitter/receiver systems were separate for the Ka-band system. (This equipment is now part of the core user equipment at DSS 13.)

Our demonstration consisted of transmitting 20 kW at X-band (7.167 GHz) and 80 W at Ka-band (34 GHz), while simultaneously monitoring the X-band (8.450 GHz) and the Ka-band (32 GHz) receive channels, using sensitive noise measurement radiometers. We were successful in showing that these four different signals could exist in the beam waveguide environment at DSS 13 and, as a result, the Cassini Radio Science team has chosen to implement this configuration at DSS 25 for the gravitational wave experiment. The risk of failure of the Cassini experiment has been greatly reduced as a result of the combined efforts of the Antenna Systems, Low Noise Amplifiers, and DSS 13 evolution Work Areas. Furthermore, future spacecraft missions are now able to plan for the use of Ka-band systems with little or no fear that the DSN can provide the appropriate support. If history repeats itself, there may someday be a spacecraft that only uses Ka-band for its telecommunication system, eliminating the need for such a four-way capability, but until then the DSN will be able to support spacecraft using S-, X-, and now Ka-band.

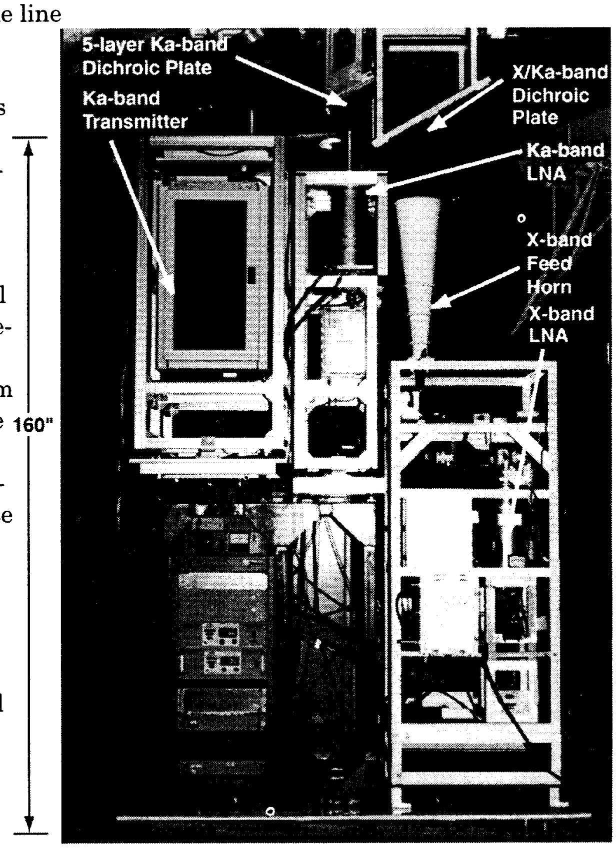

Figure 5. The X/Ka-band Front-end System at DSS 13 with a standard DSN X-band waveguide diplexer and a 5-layer Ka-band dichroic plate.

LEO-T CONTINUED FROM PAGE 9

mechanism from wind, rain, and other environmental conditions. This results in a low-cost, low-maintenance tracking antenna system. A 200-W, S-Band, solid-state transmitter is housed just under the radome base to reduce RF power loss in the cable running to the antenna feed. The electronics rack includes the telemetry receiver, command exciter, the antenna controller, and a Sparc 20 workstation; all COTS equipment. The workstation provides for automated, unattended operations of the terminal including automated scheduling, calculation of orbital trajectories, control of the antenna positioner for spacecraft tracking, automated uplink and telemetry operations, communication interfaces for remote command operations, as well as processing and distribution of spacecraft engineering and science telemetry data to the mission operations and science users of the data. In its current configuration, the terminal operates in NASA S-Band frequencies and can receive telemetry at rates up to 1.2 Mbps and uplink command at rates up to 2 kbps. However, the operating frequency and the ceilings on telemetry and uplink rates of the terminal can be easily modified by replacing the appropriate modules of the terminal with other commercially available equipment consistent with desired data rates and operating frequencies.

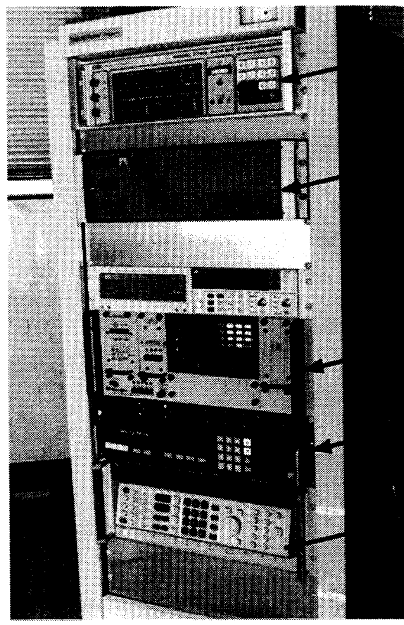

FIGURE 2. PHOTO SHOWS THE 1.22-M (4-FT) RACK HOUSING THE CONTROL WORKSTATION, COMMUNICATIONS INTERFACES, ANTENNA CONTROLLER, THE COMMAND EXCITER, AND THE ENTIRE RECEIVER.

Autonomous, Automated Operations

The software for automated operation of the terminal is based on the upgrade of SeaSpace Inc.'s telemetry software to include uplink automation, and is now available from the same vendor. The terminal provides TCP/IP interfaces for reliable networking with remote users over commercial communication links. Uplink commands can be sent in real time from the mission operations to the terminal for uplink to the spacecraft, or can be stored at the terminal for uplink during a future pass. Spacecraft telemetry received by the terminal is forwarded electronically to destinations designated for each spacecraft. After the initial set-up, the terminal auto dials an electronic bulletin board on a daily basis and retrieves orbital elements supplied by the Naval Space Surveillance Center for earth orbiting spacecraft. Based on these orbital elements, the terminal automatically generates satellite view periods, antenna-pointing predicts, and receiver/transmitter frequency predicts. The auto scheduler uses the view periods and user-defined tracking priorities to continuously track multiple spacecraft of interest. For every scheduled pass of the spacecraft, the auto scheduler wakes up the terminal two minutes before the spacecraft is to appear over the horizon. The terminal executes the automated unattended pre/in/post-pass uplink/telemetry reception routines and then waits for the next scheduled spacecraft.

Applications

The LEO-T concept has been well received by the NASA community. A large number of future missions are planning to use this concept to reduce mission life cycle costs. This class of terminals, with a 3-m dish, is capable of providing telemetry and command support to up to

CONTINUED ON PAGE 15

WADGPS CONTINUED FROM PAGE 7

technology that NASA/JPL has been developing and refining over the past 15 years. The FAA is also considering additional tasks for JPL which may further expand JPL's role in the WAAS implementation.

Meanwhile, the FAA contract has accelerated JPL's real-time GPS efforts, benefiting everyone, including NASA. In the commercial sector, interest is keener than ever in JPL's GPS software and expertise.

Thus, what began as a fairly narrow R&D effort in the DSN Technology Program has developed into a large-scale technology development that is likely to have a wide impact in a number of different areas of society. Anyone who flies on an airplane, starting in late 1998, will be able to say that this work has directly affected them. The savings to society envisioned from WAAS are unofficially estimated to be more than $12B to airlines and aviation agencies over the first 10 years, largely due to fuel savings (more efficient navigation with GPS) and higher capacity in airports (more accurate navigation and efficient scheduling). GPS should also bring much greater aviation safety where old technologies are still used for navigation. Ultimately, fully automatic landings and takeoffs are envisioned. For NASA, however, real-time GPS has the potential to dramatically lower ground tracking and navigations operations costs for satellite programs in an era when JPL and other NASA centers have been repeatedly and specifically directed to develop technologies to do exactly that. This will enable a greater percentage of increasingly scarce NASA resources to be spent in science and cutting edge technology development areas, rather than in support operational activities.

"DOUBLES" CONTINUED FROM PAGE 8

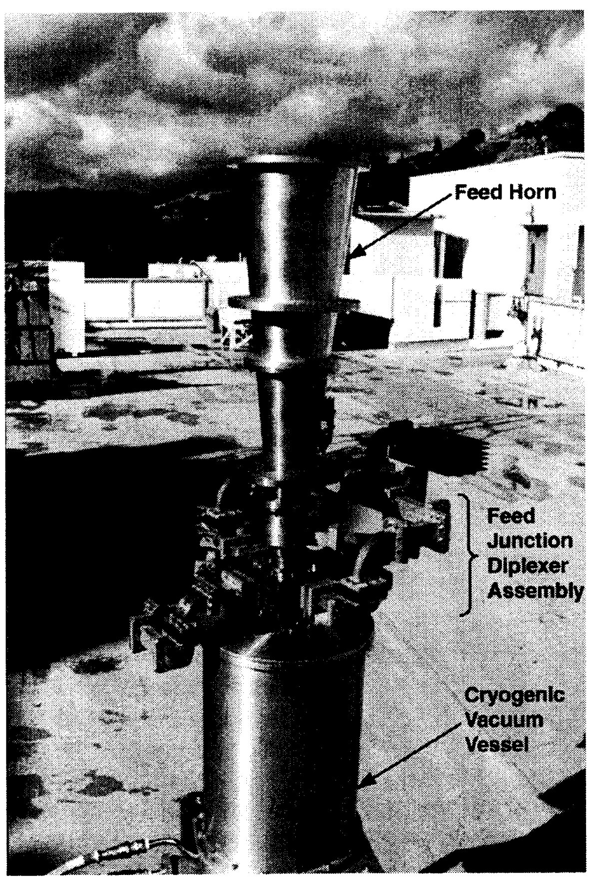

FIGURE 3. THE X-BAND FEED JUNCTION DIPLEXER ON TOP OF THE LNA SYSTEM, AS SEEN ON THE ROOF OF JPL BUILDING 238.

overall task will be completed in FY 2002. The total cost of developing and implementing this new system in all the DSN's 70-m and 34-m BWG antennas is estimated at $27 M. This investment will result in an overall DSN performance improvement equivalent to adding sixteen 34-m BWG antennas to the DSN, which would cost $390 M. Thus, the feed junction diplexer represents an extremely cost-effective approach to improving the capacity and performance of the DSN.